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Change in Walking and Body Mass Index Following Residential Relocation: the Multi-Ethnic Study of Atherosclerosis

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Abstract

Objective—To investigate whether moving to neighborhoods with closer proximity of destinations and greater street connectivity is associated with more walking, a greater probability of meeting the "Every Body Walk!" campaign goals (≥150 min/week of walking), and reductions in body mass index (BMI).

Methods—Longitudinal data from 701 participants who moved between two waves of the Multi-Ethnic Study of Atherosclerosis (2004–2012) were linked to a neighborhood walkability measure (Street Smart Walk Score®) for each residential location. Fixed effects models were used to estimate if changes in walkability resulting from relocation are associated with simultaneous changes in walking behaviors and BMI.

Results—Moving to a location with a 10 point higher Walk Score® was associated with a 16.04 minutes/week (Confidence Intervals (CI) 5.13, 29.96) increase in transport walking, 11% higher

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Contributor Statement:
J. Hirsch conceived of the research question, acquired the Walk Score data, ran the analysis and wrote the drafts of the manuscript for submission and resubmission. K. Moore linked Walk Score data with MESA data, supervised and assisted with data analysis, and provided comments and edits to drafts of the article. K. Evenson and D. Rodriguez gave input on the interpretation of the results within the existing physical activity and urban planning literatures, and provided comments on the drafted manuscript. A. Diez Roux supervised the research question, oversaw data analysis, and provided comments and edits to drafts of the article throughout the writing process.

Human Participant Protection:
The study was approved by Institutional Review Boards at each site and all participants gave written informed consent.

odds of meeting "Every Body Walk!" goals through transport walking (Adjusted Odds Ratio 1.11; CI 1.02, 1.21), and a 0.06 kg/m^2 (CI −0.12, −0.01) reduction in BMI. Change in walkability was not associated with change in leisure walking.

Conclusions—These findings illustrate the potential for neighborhood infrastructure to support health-enhancing behaviors and overall health of Americans.

Introduction

A recent report by the National Academy of Sciences showed that Americans live shorter lives and have consistently worse health than people in other high-income countries.[1] A high burden of obesity, diabetes, and cardiovascular disease was identified as contributing to the United States (US) health disadvantage.[1] The report encouraged researchers and policy makers to identify the environmental factors that may be contributing to a high prevalence of these conditions in the US, including the extent to which environmental conditions common in many communities shape the behavioral antecedents of cardiovascular disease.

Although international comparisons on levels of physical activity across countries are often inconclusive because of measurement differences,[2–4] the US differs starkly from many other high income countries in the extent to which residents engage in active travel, such as through walking or bicycling. For example, the overall bicycle share of work trips is currently three times higher in Canada than in the US[5] and the percentage of total trips by bicycle and foot are lower in the US than in Ireland, France, Great Britain, Norway, Denmark, Finland, Germany, Sweden, Spain, Netherlands, and Switzerland.[6] Research indicates that walking is the most common leisure activity performed by adults and can be an important component of physical activity.[7–10] Consistent with this evidence, in April 2013 the US Surgeon General announced the "Every Body Walk!" campaign (http://www.everybodywalk.org/) to promote walking as a simple and effective form of physical activity.

The success of campaigns to promote walking is likely to be strongly influenced by whether environmental conditions make walking feasible and safe.[11–13] In two international studies across 11 countries, fewer American participants reported having many shops within walking distance or transit stops within 10–15 minutes of their home than their international peers.[13,14] A comparison of global cities between 1980 and 1990 also revealed that cities in the US have accelerated dramatically in their dependence on the automobile, with little improvements in transit use,[15] and that per capita auto use and average gasoline consumption in the US are two times higher than in Australian cities, four times higher than in European cities, and ten times higher than in Asian cities.[15,16] Additional disparities within the US exist, with rates of walking and bicycling differing across various cities and states[6] and with high poverty and low education counties less likely to implement local pedestrian- and bicycle- related projects using federal transportation funding.[17]

Although several reviews indicate that measures of neighborhood walkability (such as self-reported walkability, accessibility to destinations, and street connectivity) are cross-sectionally associated with walking[18–20], physical activity,[18,21–23] and body mass index (BMI),[21,24,25] these studies cannot be used to draw policy-relevant causal inferences partly because of the impossibility of determining the temporal relation between neighborhood walkability and walking behavior.[18–25] Studies that examine how changes in environmental conditions are related to changes in behaviors are therefore needed.

A major challenge in estimating the causal effects of environments on health is accounting for the possibility that persons with predispositions to certain behaviors choose to live in certain types of neighborhoods.[26–31] Randomized studies of environmental interventions (such as increasing walkability) are logistically challenging and unlikely to be feasible on a large scale. Hence reliance on rigorous use of observational data is necessary. Very few cohort studies have longitudinal assessments of changes in the environment to allow investigations of associations between neighborhood change and health-related outcomes.[32–34] Because built environments often change slowly, the impact can be practically examined by investigating changes occurring as part of residential relocation. [18,30,35–45] Although longitudinal studies do not completely overcome the impact of self-selection on the associations observed,[18] they have the potential to improve causal evidence, especially if they investigate the impact of changes in neighborhood conditions on changes in health.

This paper uses data from a population-based and multi-ethnic longitudinal study conducted in six diverse areas of the US to investigate whether changes in environmental features associated with residential relocation are linked to simultaneous changes in walking for transport or for leisure in adults. The presence of such a relationship would provide strong support for consideration of land use, development, and transportation policies as levers to increase physical activity in the US. More generally, it would lend greater credence to the notion that at least some of the US health disadvantage could be the unintended consequence of a range of policy and development decisions that have engineered physically active lifestyles, such as walking, out of the lives of some American adults.

Methods

Sample

The sample consisted of participants from the Multi-Ethnic Study of Atherosclerosis (MESA), a study of 6814 US adults aged 45–84 years without clinical cardiovascular disease at baseline.[46] Participants were recruited between 2000–2002 from six study sites (Baltimore, MD; Chicago, IL; Forsyth County, NC; Los Angeles, CA; New York, NY; and St. Paul, MN). After a baseline examination, participants attended four additional follow-up examinations. Of 4592 participants who completed both Exam 3 (January 2004–September 2005) and Exam 5 (April 2010–February 2012), 934 moved between both examinations and were eligible for these analyses. An additional 233 were excluded because of missing data in at least one examination or because they did not give consent to participate in the Neighborhood Ancillary Study, leaving 701 for analyses. The study was approved by Institutional Review Boards at each site and all participants gave written informed consent.

Exposure Measure

The extent to which the environment around a person's residence is conducive to walking was assessed using a Walk Score®.[47] Walk Score® has been associated with both subjective and objective measures of walkability,[48–52] as well as with walking in cross-sectional analyses.[53–56] The Walk Score® algorithm produces scores from 0 to 100 (higher scores indicating better walkability), based on distance to various categories of amenities (e.g., restaurants, shopping, schools, parks, and entertainment) weighted based on importance to walkability and summed. Scores are then adjusted for street network characteristics such that areas with low intersection density and high block length receive lower scores.[57] The Street Smart Walk Score® used in these analyses utilizes network distances by following the streets to amenities and allows for multiple amenities within each category in order to better capture depth of choice.[57] Because historical measures were not available, Walk Score® measures created in May 2012 were linked to participants' street addresses between 2004 and 2012.

Outcome Measures

An interviewer-administered questionnaire adapted from the Cross-Cultural Activity Participation Study[58,59] was used to assess physical activity. The questionnaire was developed using extensive qualitative research[60] and has acceptable test-retest reliability and validity among a sample of women.[61] Two types of walking were assessed: walking for transport (e.g., walking to get to places such as to the bus, car, work, or store) and for leisure (e.g., walking for leisure, pleasure, social reasons, during work breaks, and with the dog). For each type of walking, participants were asked whether they engaged in that activity during a typical week in the past month, how many days/week, and hours/minutes per day they did that activity. Each type of walking was examined as a continuous variable as well as dichotomized using the cut-off of meeting "Every Body Walk!" campaign goals (≥150 min/week of walking).

BMI was calculated as measured weight in kilograms divided by measured height in meters squared. Categorical analyses were done using the World Health Organization classification system[62] of normal BMI (<25 kg/m^2), grade 1 overweight (25–29.9 kg/m^2), grade 2 overweight (30–39.9 kg/m^2), and grade 3 overweight (≥40 kg/m^2).

Covariates

Information on age, race/ethnicity, education, income, and working status was obtained by interviewer-administered questionnaire. Race/ethnicity was classified as Hispanic, non-Hispanic white, non-Hispanic Chinese, and non-Hispanic black. Participants selected their education from 8 categories which were collapsed into 3 categories: less than high school, high school diploma/GED but less than college, and college degree or higher. Participants selected combined family income from 14 categories and continuous income in US dollars was assigned as the midpoint of the selected category. Working status was categorized from ten categories of current occupation as working at least part-time or not (including employed on leave, unemployed and retired). Current marital status was self-reported and then dichotomized as "currently married or living with a partner" or "other" (including widowed, divorced, separated, and never married).

Participants were asked to rate their health compared to others their age as better, same, or worse. Arthritis was measured as having an arthritis flare-up in the past two weeks. Cancer diagnosis was determined as having a hospitalization due to cancer based on International Classification of Diseases version 9 code or self-reported cancer at any time before the exam. Season was classified as winter (January–March), spring (April–June), summer (July–September), and fall (October–December).

Statistical Analyses

Descriptive analyses contrasted movers and non-movers and compared selected characteristics across tertiles of change in Walk Score®. Chi-square tests, T-tests, or Analysis of Variance (ANOVA) were used to test for statistically significant differences ($p<0.05$) across categories, as appropriate.

Fixed-effects models[63] were used to estimate associations of within-person change in Walk Score® with within person changes in walking or BMI. This approach capitalizes on within-person variability in exposure to estimate associations.[63] These models were adjusted only for time-varying covariates (age, income, working status, marital status, self-reported health, arthritis, cancer diagnosis, and season) because fixed effects models tightly control for time-invariant characteristics. Additional models further adjusted for the other two time-varying outcomes (e.g., models for BMI were further adjusted for changes in leisure and transport walking). Naïve and multi-level marginal models were explored in sensitivity analyses; results were consistent and are not presented. All analyses were conducted in 2013 using SAS 9.2 (Cary, NC).

Results

The time between the two MESA exams (exams 3 and 5) ranged from 5.1 to 7.7 years, with a mean time of 6.3 years (Standard Deviation (SD) 0.4 years). Participants' age at the first time point ranged from 48 to 87, with an overall mean of 61.8 years (SD 9.3) (Table 1). Over half (52.4%) of participants were female. Participants' initial Walk Score® ranged from 0 to 100 with a mean of 57.7 (SD 30.6) and they moved to areas with changes ranging from 99 points lower to 93 points higher with an average of change of −7.7 (SD 31.5) between both exams.

Compared to the non-moving individuals excluded from these analyses, movers were more likely to be Non-Hispanic Chinese or Hispanic, currently working, and have a lower initial income, and less likely to be currently married ($p< 0.05$). No significant differences between movers and non-movers were found for education, self-reported health, arthritis in the past two weeks, initial and change in levels of walking or BMI, or initial Walk Score® (data not shown).

Table 2 shows selected characteristics of participants according to tertiles of the change in Walk Score® experienced as a result of residential relocation. Participants in tertile 1 had a mean decrease in Walk Score® of 41.1 points (SD 21.1), tertile 2 had a mean decrease of 5 points (SD 5.4), and tertile 3 had a mean increase of 22.8 points (SD 20.3). Individuals who had the most negative change in walkability were slightly younger, had a higher initial income, were more likely to be currently working at exam 3 or start working between exam 3 and 5, had lower initial levels of leisure walking, and had much higher initial Walk Scores®. A more positive change in walkability score between exams 3 and 5 was associated with greater increases in transport walking and with decreases in BMI. Similar patterns were observed when change in the walkability index was categorized into quartiles rather than tertiles.

Moving to a location with 10-points higher Walk Score® increased transport walking levels by 17.51 minutes per week (CI 5.96, 29.06), and increased odds of meeting "Every Body Walk!" goals through transport walking by 11% (Adjusted Odds Ratio (AOR) 1.11; CI 1.02, 1.21) (Table 3). The association between walkability and amount of transport walking was slightly attenuated or not at all changed when adjusted for change in BMI and leisure walking. In contrast, a change in Walk Score® was not associated with changes in leisure walking.

Moving to an area with 10-points higher Walk Score® was associated with 0.06 lower BMI (CI −0.12, −0.01), after accounting for changes in transport walking. This is equivalent to 0.36 lbs less for an average woman (164.1 cm) and 0.42 lbs less for an average man (178.2 cm). No association was seen between change in Walk Score® and categories of BMI.

Discussion

Moving to an area with higher walkability was associated with an increase in transport walking and a decrease in BMI in this multi-city and multi-ethnic sample. There was no association between changes in walkability and changes in leisure walking. Associations persisted after controlling for observed time-varying covariates and all observed and unobserved time-invariant covariates.

The association between change in walkability and change in transport walking extends prior research showing that living in a more highly walkable neighborhood helps individuals to maintain or increase walking levels over time.[64–67] In sensitivity analyses, there were no statistically significant differences in the effect of change in walkability on change in walking by length of time in the new residence (data not shown). This may indicate that the effect of moving to more walkable neighborhoods does not diminish or increase over time. The increase in transport walking after moving to a more supportive environment is concordant with previous research in other countries[40] and select US cities.[37–39,42] By using data from a multi-ethnic and multi-city sample, this research provides evidence that environmental modifications may be an important strategy for increasing walking across a broader US context.

The lack of associations between change in walkability and change in leisure walking is consistent with previous cross-sectional research[68] and with the methods used to create the walkability index. Walk Score® primarily measures access to destinations, which influences whether errands or other transportation can occur on foot, but may not capture other elements of the built environment that encourage leisure-time walking, such as aesthetic quality, street traffic, or availability of walking trails. Differences in the associations of walkability with transport and leisure walking highlight the importance of matching environmental measures to specific behaviors when studying associations between health behaviors and the environment.[69]

The finding that moving to a more walkable neighborhood was associated with declines in BMI illustrates the potential of environmental interventions to influence health outcomes and cardiovascular risk. Previous research on neighborhood walkability and weight trajectories show the importance of the environmental context in maintaining a healthy weight,[64,70–73] but longitudinal evidence linking changes in the environment to changes in weight and BMI has been inconsistent.[36,44,74] Conflicting results may be due to different definitions of neighborhoods or the types of measures of the built environment used. Prior studies examined radii around homes,[36] city-designated neighborhoods,[74] or counties,[44] all of which may not capture the neighborhood environment in the same way as the Walk Score®. Additionally, self-reported evaluations of walkability[74] or land cover data,[36,44,74] may represent different aspects of the environment than the street distances to specific destinations used in the Walk Score®. In our analyses, the effects of change in walkability on change in BMI was not reduced after controlling for change in transport and leisure walking, suggesting that the BMI effect is not mediated through effects on walking. Measurement error in walking may have affected our results. In addition, moving to more walkable areas may also be associated with greater bicycling or transit use. It is also possible that more walkable locations have increased options for healthier food and that dietary changes were also associated with moving to more walkable areas.

Recent research examines the roles of lifestyle and preferences in the selection of neighborhoods.[26,29,31,34,75] Evidence suggests that walkability is an important consideration when individuals select residential locations,[26,76–78] that support for more walkable neighborhoods is increasing nation-wide,[79] and that preference for easily walkable neighborhoods may be associated with BMI.[34] We have no information on reasons for moving or preferences in our sample. Previous studies that have accounted for residential preferences or predispositions towards active transport found limited attenuation of results.[35,40] To the extent that preferences and predispositions are stable person-level traits, they are accounted for by our use of fixed effects models that account for all stable person level attributes. Additional longitudinal evidence is needed that illustrates whether walking behavior responds to changes in neighborhood walkability for individuals who do not move.

Limitations

Self-reported measures of walking may not be as accurate as those assessed objectively using pedometers or accelerometers. However, since our analyses investigated change in walking within participants, stable over- and under-estimates of walking by a given person are accounted for. This study was limited to a middle-age and older adult population of movers and may not be generalizable to younger individuals who remain in the same residential location. The use of Walk Score® from 2012 for both pre- and post-move residential locations relies on the assumption that Walk Scores® for locations remained stable over time. This assumption may have introduced measurement error and resulted in attenuations of the association between changes in Walk Score® and changes in the outcomes. This analysis could not control for or examine the effect by study site due to small sample sizes. In our analyses, the persons experiencing the greatest reductions in Walk Score® as a result of the move were also those with the highest starting levels. It is plausible that the effect of a given change is modified by the starting level. However, limited sample size precluded us from investigating this important question. Limited sample size also prevented us from investigating whether a minimum change in the environment is necessary for an effect on walking behavior (i.e., whether a threshold effect is present). In addition, although we controlled for several time varying covariates and our models tightly control for time invariant person characteristics, residual confounding by other time varying factors cannot be ruled out.

Conclusions

This study provides longitudinal evidence that transport walking and BMI shift favorably in response to changes in the walkability of the residential neighborhood. Individuals who move to an area with higher walkability walk more for transport and weigh less than prior to their move. These findings illustrate the potential for local infrastructure to support health-enhancing behaviors and highlight the potential effects of non-health policies, including urban planning, transportation policy, and economic development policy, on health related outcomes.[80] Contrasts between different neighborhood environments within the US give insight into the factors that may be limiting American health in comparison to other countries. Increasing effort to work collaboratively across disciplines must be pursued in order to facilitate changes in the neighborhood environment that could improve the health of US communities.

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Table 1

Selected characteristics of participants included in analyses (n=701), Multi-Ethnic Study of Atherosclerosis (MESA) in baseline (exam 3, Jan 2004–Sept 2005) and follow up (exam 5, April 2010–Feb 2012).

	Baseline	**Follow Up**
	Mean (SD[a]) or Percent	**Mean (SD[a]) or Percent**
Age	61.8 (9.3)	68.1 (9.3)
Female	52.4%	------[b]
Race/ethnicity		
Non-Hispanic White	36.5%	------[b]
Non-Hispanic Chinese	17.1%	------[b]
Non-Hispanic Black	23.7%	------[b]
Hispanic	22.7%	------[b]
Education		
Completed HS/GED or less	30.4%	------[b]
Some college, technical/ associates	27.8%	------[b]
College or higher	41.8%	------[b]
Income (in thousands)	50.4 (35.0)	49.7 (35.6)
Currently married	58.9%	54.1%
Currently working	61.2%	47.2%
Health Compared to Others		
Better	58.6%	58.9%
Same	37.0%	35.1%
Worse	4.4%	6.0%
Arthritis in the past 2 weeks	12.4%	17.3%
Cancer diagnosis	9.3%	14.6%
Transport Walking (mean min/week)	237.1 (358.3)	306.5 (436.4)
Enough to meet “Every Body Walk!” goals[c]	43.1%	50.6%
Leisure Walking (mean min/week)	181.4 (298.3)	238.4 (367.4)
Enough to meet “Every Body Walk!” goals[c]	36.5%	45.4%
BMI[a] (kg/m^2)	28.2 (5.5)	28.4 (5.6)
Normal[d]	31.1%	29.2%
Grade 1 Overweight (25–29.9 kg/m^2) [d]	36.5%	37.7%
Grade 2 Overweight (30–39.9 kg/m^2) [d]	29.4%	30.0%
Grade 3 Overweight (≥40.0 kg/m^2) [d]	3.0%	3.1%
Walk Score[a]	57.7 (30.6)	50.0 (31.5)

[a]SD= Standard Deviation; BMI=Body Mass Index; Walk Score= Street Smart Walk Score from Front Seat Management, LLC

[b]These are time-invariant variables, percentages are the same between the two exams

[c]Meeting "Every Body Walk!" goals defined by ≥150 min/week

[d]BMI categorized using WHO categories

Table 2

Selected characteristics of participants included in analyses by tertile of change in walkability, Multi-Ethnic Study of Atherosclerosis (MESA) in baseline (exam 3, Jan 2004–Sept 2005) and between baseline and follow up (exam 5, April 2010–Feb 2012).

	Change in Walk Score			
	Tertile 1[a]	**Tertile 2**	**Tertile 3**	
	(n=236)	**(n=227)**	**(n=238)**	
	Mean (SD[b]**) or Percent**	**Mean (SD**[b]**) or Percent**	**Mean (SD**[b]**) or Percent**	***p*-value**[c]
Age	60.7 (9.4)	62.2 (9.1)	62.5 (9.4)	0.10
Female	55.1%	51.1%	50.8%	0.59
Race/ethnicity				
Non-Hispanic White	39.0%	35.7%	34.9%	
Non-Hispanic Chinese	17.4%	15.4%	18.5%	
Non-Hispanic Black	24.6%	22.5%	24.0%	
Hispanic	19.1%	26.4%	22.7%	0.64
Education				
Completed HS/GED or less	25.4%	34.4%	31.5%	
Some college, technical/ associates	28.4%	27.3%	27.7%	
College or higher	46.2%	38.3%	40.8%	0.28
Initial Levels (exam 3):				
Income (in thousands)	54.9 (35.7)	47.8 (34.4)	48.2 (34.6)	**0.05**
Currently married	62.7%	57.3%	56.7%	0.34
Currently working	68.2%	55.1%	60.1%	**0.01**
Health Compared to Others				
Better	58.5%	58.2%	59.2%	
Same	36.4%	35.7%	38.7%	
Worse	5.1%	6.2%	2.1%	0.25
Arthritis in the past 2 weeks	13.1%	13.2%	10.9%	0.69
Cancer diagnosis	8.9%	10.6%	8.4%	0.72
Transport Walking (mean min/week)	249.1 (372.2)	246.6 (374.1)	216.1 (328.2)	0.16
Median, interquartile range	120.0 (280.0)	120.0 (280.0)	105.0 (210.0)	
Enough to meet “Every Body Walk!” goals [d]	45.8%	44.1%	39.5%	0.36
Leisure Walking (mean min/week)	158.8 (273.6)	186.0 (293.9)	199.4 (324.6)	0.08
Median, interquartile range	60.0 (210.0)	120.0 (225.0)	97.5 (240.0)	
Enough to meet “Every Body Walk!” goals [d]	29.7%	40.1%	39.9%	**0.03**
BMI[b] (kg/m^2)	28.3 (5.6)	28.0 (5.4)	28.3 (5.6)	0.77
Normal[e]	31.4%	33.9%	28.2%	
Grade 1 Overweight (25–29.9)[e]	36.0%	35.2%	38.2%	

	Change in Walk Score			
	Tertile 1[a]	Tertile 2	Tertile 3	
	(n=236)	(n=227)	(n=238)	
	Mean (SD[b]) or Percent	Mean (SD[b]) or Percent	Mean (SD[b]) or Percent	*p*-value[c]
Grade 2 Overweight (30–39.9)[e]	28.4%	28.2%	31.5%	
Grade 3 Overweight (≥40.0)[e]	4.2%	2.6%	2.1%	0.69
Walk Score	69.8 (21.7)	62.8 (31.6)	40.7 (30.0)	**<0.001**
Change (between baseline and follow up):				
Time between exams (years)	6.4 (0.4)	6.3 (0.4)	6.3 (0.3)	**0.01**
Change in Income (in thousands)	−1.1 (23.9)	1.2 (26.4)	−1.9 (23.0)	0.38
Currently married				
No longer married[f]	7.2%	11.5%	12.2%	
New marriage[f]	3.8%	6.6%	5.9%	0.18
Currently working				
Stopped working[f]	19.9%	11.9%	20.2%	
Started working[f]	4.7%	3.5	2.1%	**0.04**
Health Compared to Others[g]				
Declining Health	22.6%	25.4%	24.2%	
Increased Health	27.1%	27.0%	31.5%	0.86
Arthritis in the past 2 weeks				
No longer have flair-up	6.8%	7.5%	5.9%	
New flair-up	11.9%	12.3%	10.5%	0.91
New cancer diagnosis	4.2%	5.3%	6.3%	0.60
Change in Transport Walking (mean min/week)	−9.3 (460.9)	128.5 (533.3)	91.2 (462.2)	**0.007**
Median, interquartile range	−30.0 (257.5)	0.0 (305.0)	30.0 (285.0)	
Change in Leisure Walking (mean min/week)	37.4 (361.5)	87.9 (420.9)	46.8 (417.7)	0.36
Median, interquartile range	7.5 (210.0)	0.0 (240.0)	0.0 (180.0)	
Change in BMI[b] (kg/m^2)	0.5 (2.2)	0.2 (1.9)	−0.1 (2.6)	**0.01**
Change in Walk Score[b]	−41.1 (21.1)	−5.0 (5.4)	22.8 (20.3)	------[h]

[a]Tertile 1 defined as Walk Score change ≤−16; tertile 2 defined as Walk Score change >−16 and ≤1; tertile 3 defined as Walk Score change >1.

[b]SD= Standard Deviation; BMI=Body Mass Index; Walk Score= Street Smart Walk Score.

[c]*p*-value from Chi-square or fisher's exact test for categorical variables and appropriate ANOVA or Kruskal-Wallis for continuous variables across tertiles of change in Walk Score.

[d]Meeting "Every Body Walk!" goals defined by ≥150 min/week

[e]BMI, World Health Organization Categories

[f]Percentage for change in marriage and working status are over the entire sample

[g]Declining health measured as reporting a lower category of health compared to others at follow up than baseline (going from “better” to “same” or “worse” or going from “same” to “worse”); Increasing health measured as reporting a higher category of health compared to others at follow up than baseline (going from “worse” to “same” or “better” or going from “same” to “better”)

[h]Did not compare across tertiles, as this were used to determine tertile

Table 3

Within-person change in transportation walking, leisure walking, and BMI[a] associated with an increase in walkability (measured as a 10-unit increase in Walk Score), Multi-Ethnic Study of Atherosclerosis (MESA) between 2004–2012.

	Unadjusted		Adjusted[b]		Further Adjusted[c]	
	Change (CI[a])	**p-value**	**Change (CI[a])**	**p-value**	**Change (CI[a])**	**p-value**
Transport Walking						
Mean change in minutes	**17.31 (5.84, 28.78)**	**0.003**	**17.51 (5.96, 29.06)**	**0.003**	**16.04 (5.13, 26.96)**	**0.004**
Odds ratio of meeting “Every Body Walk!” goals	**1.11 (1.02, 1.20)**	**0.01**	**1.11 (1.02, 1.21)**	**0.01**	**1.11 (1.02, 1.21)**	**0.01**
Leisure Walking						
Mean change in minutes	6.12 (−3.34, 15.57)	0.20	6.51 (−3.03, 16.05)	0.18	1.26 (−7.85, 10.36)	0.79
Odds ratio of meeting “Every Body Walk!” goals	0.94 (0.88, 1.02)	0.14	0.95 (0.88, 1.03)	0.20	0.94 (0.87, 1.02)	0.12
BMI[a]						
Mean change in BMI	**−0.06 (−0.11, −0.00)**	**0.03**	**−0.06 (−0.11, −0.00)**	**0.04**	**−0.06 (−0.12, −0.01)**	**0.02**
Odds ratio of becoming a higher BMI category	1.00 (0.97, 1.03)	0.90	1.00 (0.97, 1.02)	0.85	1.00 (0.97, 1.02)	0.79

[a] Body mass index (BMI); 95% Confidence Intervals (CI)

[b] Adjusted for time-varying age, income, season, working status, current marriage status, health compared to others, arthritis in the past two weeks, and cancer diagnosis.

[c] Additionally adjusted for the other two time-varying outcomes shown in the table (e.g., the model using BMI as an outcome is additionally adjusted for transportation and leisure walking).